Physical properties of briquettes based on charcoal from selected biomass

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Abstract

Agriculture biomass has the potential to be used as feedstock for biomass production as energy resources in the future. In this study, the physical properties of different kind of biomass based charcoals briquettes with the mixing ratios between the biomass charcoal and binding agents of 90:10, 80:20, and 70:30 was determined. Charcoal of groundnut shell, durian shell, and cassava peel were used to produce briquette biomass based charcoals. The binding agent was found to significantly affect to the physical properties. Moisture, ash, volatile matter and compressive strength increased with increasing the amount of binding agent. The briquettes which have similar properties with the SNI standard are briquette from groundnut shell for lowest (10%) amount of binding agent. The charcoal from groundnut shell had the highest silica content followed by durian shell and cassava peel. As the amount of silica is high, the carbon content and the calorific value also is high. Silica also can be converted to silicate which is high strength material and influenced to the compressive strength of the briquettes.

Keywords: physical properties, briquettes, biomass, groundnut shell, durian shell, cassava peel

1. Introduction

Biomass energy are renewable energy with environmentally friendly sources were developed to overcome the scarcity of energy resources in the future because its supplies are not limited. Biomass is organic materials which are commonly use wood and organic waste from household, industrial, and agriculture as sources. Biomass is probably oldest source of energy after the sun. Since thousands years ago, people use wood by burned to heat their homes and cook their food [1-2]. Now a days, there are many modern applications of biomass for energy including: a) household application such as improved cooking stove, use of briquette, use of biogas, use of ethanol; b) cottage industrial application such as brick making, bakeries, ceramic etc.; and c) large industrial application such as electricity generation, pulp boiler etc [1-4].

Most of biomass waste has a higher moisture content and lower density, thus making them technically unsuitable for direct use due to combustion and handling problems. Conversion of biomass waste to briquettes is a solution which can help to increases the volumetric calorific value of a fuel, reduces the cost of transportation, collection, and storage, and can help in improving the fuel situation in rural area. Briquetting of residues take place with the application of pressure, heat and binding agent by densification of the loose biomass materials to produce the briquettes. Two different type of densification technology are currently in use. The first, called pyrolizing technology of biomass by mixed with binder and then made into briquettes by casting and pressing. The second technology is direct extrusion type, where the biomass is dried and directly compacted with high heat and pressure.

In general, natural binders such as lignin, protein and starches present in the biomass enhances the bonding between particles during densification process. At the high pressures, particles are brought close together, causing inter-particle attraction forces, and the natural binding components in the biomass are squeezed out of the cells, which make solid bridges between the particles. The biomass composition, the particle size, moisture content,

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percentage of fines, type of densification machine, die diameter, temperature, and pressure are major variables that contribute to the quality of briquetting [1-5]. The effect of composition of binder to the charcoal biomass is one of the major variables in order to understanding the compaction behavior of briquettes [3-5]. In this study the effect of binder composition to the physical properties of groundnut shell, cassava shell, and Durian shell based charcoal briquettes was prepared by pyrolizing technology were investigated. A binder is used for strengthening the briquettes which was made by blending of clay soil with cassava powder.

2. Experiment

Groundnut shell, durian shell and cassava peel are collected from cultivated area in South Sulawesi Province, Indonesia. These raw materials were cut into short pieces and sun dried (1 day for groundnut shell and 4 days for cassava peel and durian shell). Figure 1 shows the processes for obtain briquettes in this study from collection and drying of biomass, carbonization, charcoal, binder preparation and mixing, and production of briquettes.

Figure 1: Briquetting process in this study

2.1. Carbonization Process

For carbonization, the pyrolysis process in a furnace was used during 1 hour for groundnut shell and 2 hours for cassava peel and durian shell. The Chemical compositions of the biomass charcoals powder were obtained by using energy disperse X-ray fluorescence (EDXRF) spectroscopies are shown in Table 1.

A binder is used for strengthening the briquettes. For preparation of binding material, blending cassava powder, clay soil, and water in the ratio 2:1:7, respectively and allow it to disperse without any clumps. The solution was heated for 15 minutes and do not allow it to boil. The final condition of the solution can be identified by the stickiness.

2.2. Briquetting Process

The charcoals prepared were firstly milled and sieved through screens to obtain the homogenous particle size of the charcoal around 150-400 µm. Thereafter, the charcoal biomass (cassava peel, groundnut shell, and durian shell) individually were well blended with binding solution at the mass mixing ratio of 70:30, 80:20, and 90:10 (charcoal biomass: binder), particle of charcoal must coated with the binder. This process enhances charcoal adhesion and produce identical briquettes. The charcoal biomass mixture with binder were press manually at ambient temperature (see Fig.1), designed for the purpose.

Table 1
Chemical composition of the biomass charcoal

Oxides (%)	Cassava Peel	Groundnut Shell	Durian Shell
SiO_2	29.64	69.67	62.00
Al_2O_3	12.59	26.98	35.70
Fe_2O_3	1.28	0.00	0,00
CaO	22.26	0.00	0.00
MgO	31.93	0.00	0.00
SO_3	2.30	3.35	2.30

2.2. Characterization Physical Properties

Percentage of moisture determined by thermo-gravimetric methods by drying the briquettes in electrical furnace at 100-105^{o}C for 2 hours. The moisture is calculated from the mass ratio between the dry sample and the wet sample.

Inorganic substance that remains after completed combustion of briquettes called ash. Mass of ash content determined after calcinations the briquettes in programmable electrical furnace for 30 minutes to increasing the temperature from 500^{o}C to 900^{o}C, kept for 2.5 hours at highest temperature, and then for 30 minutes decreasing temperature to room temperature. The ash content is the mass ratio between the heated sample and non heated sample.

Volatile matter, carbon content, caloric value, and compressive strength are another physical property which is important to know caused these properties influenced to the quality of briquettes. Volatile matters are component in briquettes which making long time duration of fire. As the amount of volatile matter increase the duration times of fire also increase but resulting fogging during the briquettes are burning. The ideal amount of volatile matter based Indonesian national standard (SNI) 01-6235-2000 is maximum 15% [6]. Carbon is one of the component in briquettes does not form a gas when burned. Ash, volatile matter, and carbon content are highly influence to the caloric value of briquettes. Parr oxygen bomb calorimeter and strength test was used to determine the caloric value and compressive strength of briquettes, respectively. All characterization system was performed in Physics Laboratory, PT Semen Tonasa, Pangkep, Sulawesi Selatan, Indonesia.

3. Results and Discussion

Chemical composition of silicon dioxide (SiO_2) and aluminium oxide (Al_2O_3) as shown in Table 1 are dominated in charcoal of groundnut shell and durian shell. For charcoal from cassava peel, the amount of metal oxides; MgO, SiO_2, CaO, Al_2O_3, and Fe_2O_3 are; 31.93%, 29.64%, 22.26%, 12.59%, and 1.28%, respectively.

Table 2 and Figure 2 were shows physical properties of biomass briquettes from groundnut shell, durian shell, cassava peel, and SNI data for comparison [6].

Table 2
Physical properties of biomass briquettes in this study and Indonesian national standard (SNI) No:01-6235-2000 for comparison.

Sample	Moisture (%)	Ash (%)	Volatile Matter (%)	Carbon (%)	Calorific (cal/gram)	Compressive strength (N/m^2)
A1(90:10) Groundnut shell	5.57	6.09	11.82	76.55	5307.78	30769.23
A2(80:20) Groundnut shell	5.86	7.39	16.36	70.39	5255.03	39316.23
A3(70:30) Groundnut shell	7.05	8.75	23.19	61.04	5745.04	50427.35
B1(90:10) Cassava peel	7.85	7.40	12.55	72.19	4453.44	9302.32
B2(80:20) Cassava peel	9.48	9.52	22.51	58.49	4965.22	23255.81
B3(70:30) Cassava peel	9.52	16.22	28.99	45.27	4748.96	29457.36
C1(90:10) Durian shell	5.91	7.63	7.95	78.51	5227.00	21503.5
C2(80:20) Durian shell	11.08	8.54	12.43	67.95	5083.61	23157.7
C3(70:30) Durian shell	11.84	10.23	13.52	64.41	5059.00	38044.8
SNI(01-6235-2000)	**Max. 8**	**Max.8**	**Max.15**	**Min. 69**	**Min. 5000**	

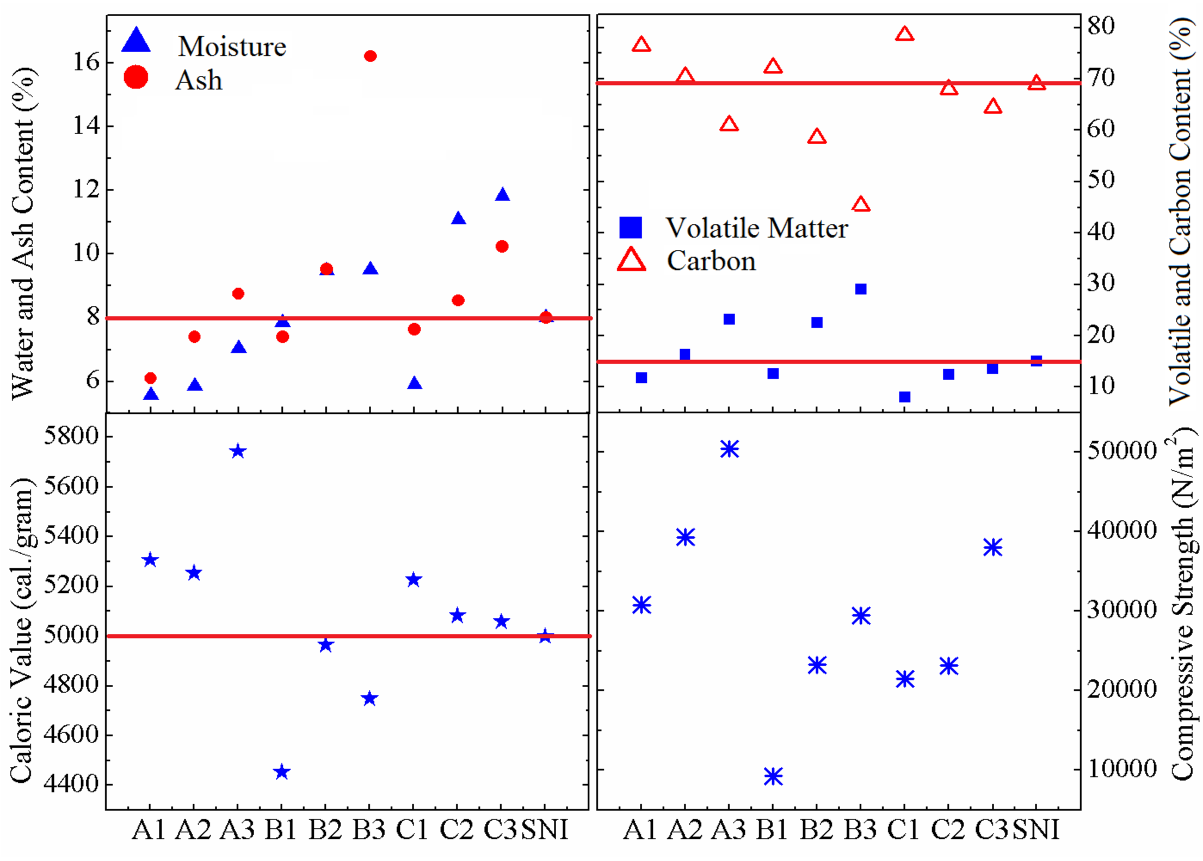

Figure 2: Physical properties (symbols) of biomass briquettes in this study and Indonesian national standard (SNI) No:01-6235-2000 (lines) for comparison. The line indicates SNI with the maximum value for moisture content, ash, and volatile matter and the minimum value for carbon and caloric.

Table 2 and Figure 2 shows the moisture, ash dan volatile matter was increased with increasing the amount of binding agent. The lowest amount of binding agent that is 10% of the briquettes samples in this study that meets the SNI standard [6]. Carbon content was varies for each briquettes with the lowest carbon content are cassava peel. Carbon content decreases with increasing the amount of binding agent for all type of briquettes in this study. The lowest calorific value of briquettes is made from cassava peel, this due to the lowest carbon content in cassava peel. Carbon content was depended by the amount of silica content in biomass. Chemical compositions of charcoal biomass as shown in table 1. Calorific value of groundnut shell and durian shell meet SNI standards, although its value does not show a linier value with increasing the amount of binding agent. The amount of silica was influenced to the carbon content and caloric value, as the amount of silica is high, the carbon content and the caloric value also is high. Table 2 and figure 2 shows the silica content of charcoal from groundnut shell had the highest silica content followed by durian shell and cassava peel, respectively.

Compressive strength is a value that indicates the resistance to the pressure of briquettes during the transport from the site of production to point of use. Comparison between each briquettes indicated that groundnut shell briquette had the highest compressive strength followed by durian shell and cassava peel briquettes respectively. It was also found from figure 2 and Table 2 that compressive strength increased with increasing the amount of binder in briquettes. It is generally accepted that silica is a chemical component of groundnut shell and it can be converted to silicate, a high strength compound through the oxidation reaction. Silicate is a material with high strength, which caused the highest compressive strength of the briquettes based on biomass from groundnut shell.

4. Conclusions

Charcoal of groundnut shell, durian shell, and cassava peel were used to produce biomass based charcoals briquettes. The effect of composition of charcoals with binding agent to the physical properties of charcoals briquettes was reported. The binding agent was found to significantly affect to the physical properties. Moisture, ash, volatile matter and compressive strength increased with increasing the amount of binding agent. The briquettes which have similar properties with the SNI standard are briquette from groundnut shell for lowest amount of binding agent. The charcoal from groundnut shell had the highest silica content followed by durian shell and cassava peel. As the amount of silica is high, the carbon content and the caloric value also is high. Silica also can be converted to silicate which is high strength material and influenced to the compressive strength of the briquettes.

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